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pv magazine special

Stepping into the PV home of the future

The smart move toward energy independence

The smart home in focus

Decentralized agents of the new energy paradigm

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Storage, EV's & inverters

The emerging PV trifecta

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SPECIAL EDITION DEVELOPED IN PARTNERSHIP WITH GROWATT

powering tomorrow Growatt

powering tomorrow
Growatt

FUTURE READY SMART HOME

MIN 2500-6000TL-XH

- Better User Experience
  OLED Display
  Touch Button
- Future-Proof
  Battery Ready
- Aerospace Grade Material
  Light and Flame-Retardant
- Easy Maintenance
  Online Smart Service
- Safe & Reliable
  Type II SPD, AFCI Optional

Ten years of innovation and growth

Photo: pv magazine/Thomas Beetz

At **pv magazine** we are proud to have worked closely with Growatt to produce this special edition in 2020, the tenth year since the founding of the Shenzhen-based manufacturer. Growatt and its founder, chairman and president David Ding have been pioneers in the global PV industry, being the first Chinese inverter manufacturer to focus on overseas markets soon after the company was established in 2010.

By 2011, the company was already the leading PV inverter supplier to the booming Australian market with a 23% market share. In 2014, Growatt raised eyebrows by achieving 99% efficiency with its 20 KW inverter and three years later in 2017, the company passed the one million mark for shipments.

In its home market of China, Growatt was not only recognized as a National High Technology Enterprise in 2013, but as the Chinese downstream market developed a robust residential segment, Growatt became the leading supplier to this segment with a 30% market share. As this segment is expected to grow from 5 GW in 2019 to 7 GW this year, it will constitute the manufacturer's leading market in terms of volume.

Growatt shipped more than 5GW of products in 2019, and is opening a state-of-the-art production hub in Huizhou near Shenzhen this year. The new facility will bring the company's annual production capacity to 10 GW, and as Ding pointed out to **pv magazine**, there is ample room to grow the production even further. He also cited the company's growing energy storage business, which is set to boom with a continuing decline in lithium-ion battery prices and an increasing number of customers appreciating the added self-consumption and grid independence that comes with adding storage to a PV system.

Growatt's emphasis on quality is fundamental to the company's global success. Its five-step quality system involves rigorous design engineering, components selection, testing procedures, environment and reliability engineering, and manufacturing engineering. This system will serve both the company and its customers well as battery storage solutions are added to the product portfolio.

Independent third-party testing organizations like TÜV Rheinland have verified the efficiency and performance stability of Growatt's inverters. In 2019, TÜV Rheinland bestowed the "All Quality Matters" award to Growatt's new 80 kW commercial and industrial (C&I) inverter, which ranked first in its PVE test program for high power C&I inverters. We can expect further endorsements in the future as Growatt expands its work with third party testing organizations across the world.

You will find plenty of information on Growatt's technology, quality systems, product portfolio, and project track record in this publication – and we can only wish that this special edition is read in as many countries as Growatt products are harvesting clean energy. The number of countries is well over one hundred, with even Antarctica being home to at least one Growatt inverter. That in itself is a reference for product reliability!

Eckhart K. Gouras, Publisher, pv magazine

Imprint

Special publication

A special publication produced by
pv magazine group GmbH & Co. KG
in partnership with
Growatt

Publisher

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Photo: Growatt

Solar+storage in Brazil

From isolated communities to residential rooftop projects developed in-basin – off-grid is becoming mainstream.

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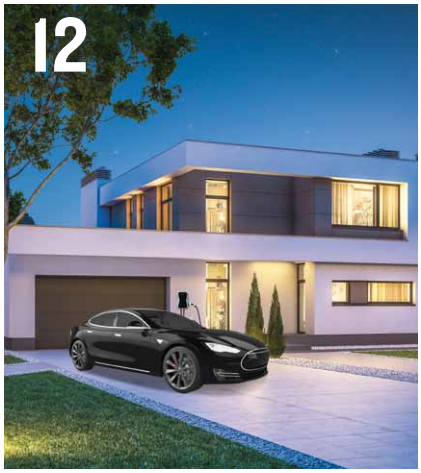

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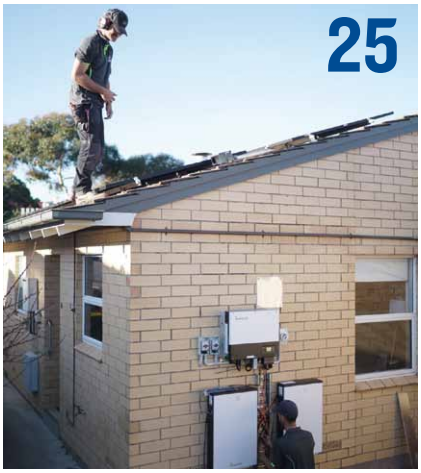

Photo: Growatt

The PV home of the future
Smart energy technologies are putting DG at the forefront of the energy transition.

Bringing O&M costs down
Digitalization is bringing forth new opportunities for remote O&M.

Inverter uptake down under
The marriage of inverter and storage technologies bolster Australia's already mature PV market.

Applications & Installations ▸

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Smart is the name of the

Set out on a path to make a difference in the world's energy future, young entrepreneur David Ding started Growatt a decade ago at the age of 30. Since then, his company has moved quickly to become one of the largest rooftop inverter manufacturers in the world. High in energy and swift to make bold moves, Ding is on a mission to shift the role of user-side solar generators – to become active participants of the new energy future.

What inspiration led you up to the starting point of Growatt – and are the same foundational elements alive today?

I began my career working for global power giant Eaton as an R&D engineer in its PV department in 2005. But by 2010, I was ready to do something bigger. The solar market was just getting kicked off at this time, and I had confidence in the future of the industry – and really wanted to do something significant for mankind. So I decided to establish my own enterprise at the age of 30, and set out on a mission to provide high-quality Chinese PV inverters for the world.

In 2010, solar was still an emerging industry and was primarily being deployed in European countries, the U.S., and Australia. After careful consideration I decided to enter the Australian market. There weren't any big brands in the market yet, so I moved quickly – the market never waits. Looking back, the commitment of our R&D team was tremendous to develop new quality PV inverters. The entire team was working overtime to test the models and keep improving them. It took us less than three months to develop a new inverter in accordance with Australian grid standards. Since then, speed is the gene of our company. To date, we keep an impressive track record of developing new inverters in response to market demands. Dedication to innovation, focus on market demands, industry trends, a commitment to product reliability and excellent service – these have been the drivers behind Growatt's fast and robust growth for the past ten years.

With so many inverter manufacturers on the market, how do you stay competitive?

We have deployed a global strategy, but stay specialized in local services. We now have 13 subsidiaries and six large warehouses around the world with regional teams for marketing, technical support, and after-sales service. Taking Europe as an example, Growatt can deliver replacements to customers within 48 hours. We take efficiency and customer service seriously. So, we upgrade products quickly according to the demand of the market and clients – and then invest 10% of our revenue in R&D every year. Of our 1,200 employees, 200 of them are R&D engineers. And then, of course, product quality management. We pursue a goal of zero defects – which requires a stringent QC system. Growatt set up a fully automatic assembly line for key components and set up our own production lines for self-developed products – which ensure quality and efficiency – but also reduces costs.

"A new lifestyle of 'smart+comfort' is the future. It's really built upon IoT, Big Data and AI"

While solar is growing in scale, Growatt has decided to focus on the distributed generation (DG) market. Why?

The DG solar market is growing rapidly, it has already taken a significant share – and we believe it will become even stronger in the future. There are definitely advantages in having a core business segment. We focus on user-side smart energy solutions, especially for the residential, commercial and industrial rooftop projects – which is the realm where we have the greatest opportunity to grow and become stronger. While a leader in DG solar, we are not limited to this segment.

We developed the MAX 50-100K string inverter for small to medium commercial and ground-mounted plants, which took the top ranked position in TÜV Rheinland's PVE test program of All Quality Matters award for high power commercial and industrial PV inverters. And our latest MAX 175-253K 1500V inverter product has 15 MPPTs and a DC/AC ratio that can reach up to 2.0.

It has become increasingly popular to install storage with rooftop PV installations. How has your company adapted to this and what are your future plans for solar+storage?

We were one of the first Chinese inverter companies to develop energy storage products. Although the storage market wasn't big at that time, we believed that solar+storage would be the future. Currently, our off-grid and energy storage inverters cover a capacity range of 1 kW to 30 kW. Last year, we launched the first storage-ready inverter in Aus-

game


Photo: Growatt

David Ding founded Growatt ten years ago at the age of 30.

tralia. Due to high battery prices, customers are currently using on-grid inverter applications. But in the future, as batteries become even cheaper, customers can easily upgrade to storage systems. In Australia and Europe, the solar+storage inverter solution is already being well received by users. We are doing a lot of work in optimizing storage systems to support smart grids with fast response and smart dispatch.

Smart is the name of the game for the industry right now. With digitization, IoT, and AI advancements, what does the PV home of the future look like?

A smart home includes many aspects – household appliances, access controls, security systems, etc. The energy management system acts as the brain of the PV system while the inverters are like the heart, pumping blood, or electricity, to the various smart devices. They also assume the responsibility of security for the entire system. The inverter monitors the grid and provides protection, and is also responsible for friendly interaction with users.

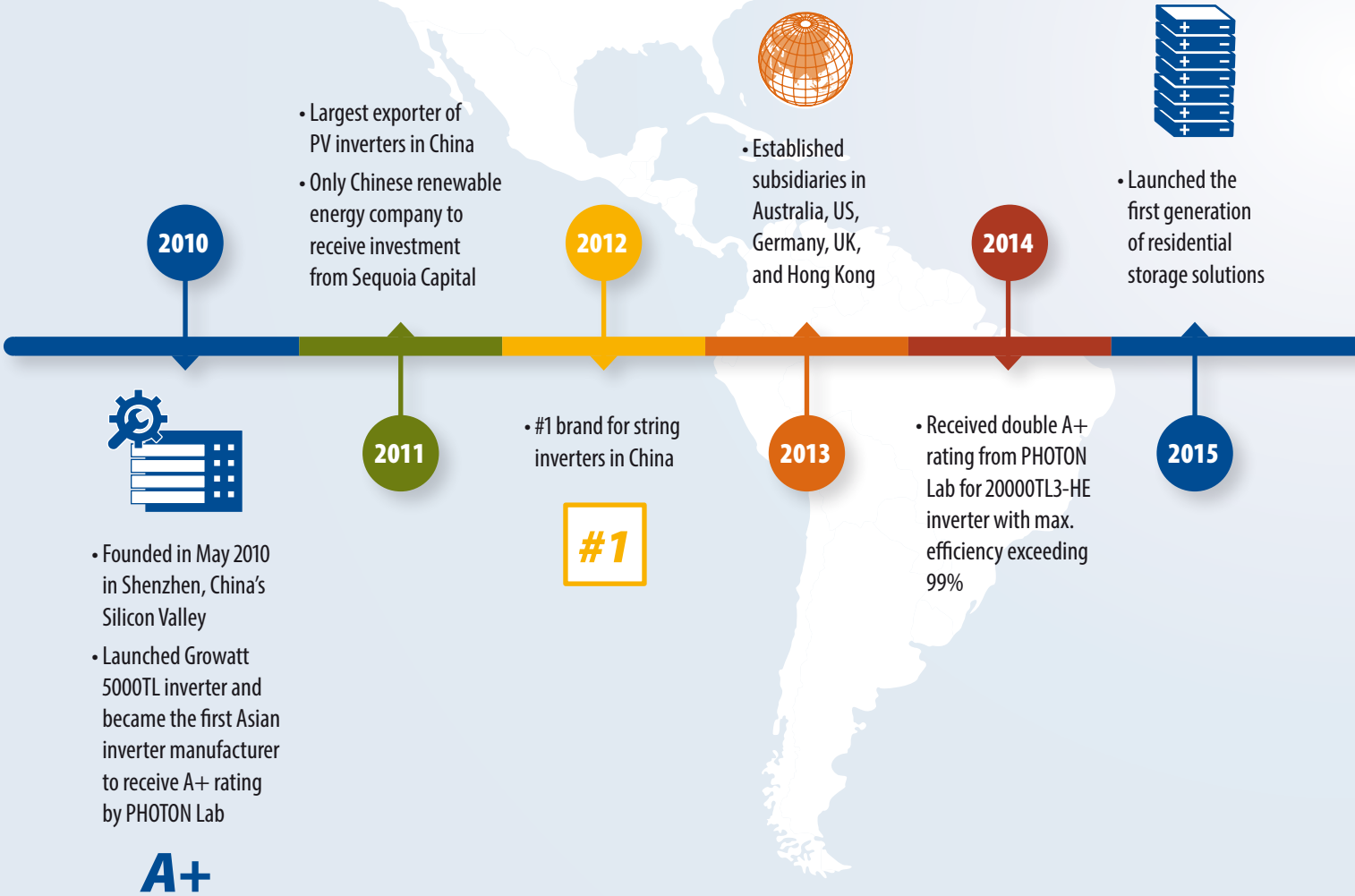
A new lifestyle of 'smart+comfort' is the future. It's really built upon IoT, Big Data and AI, and it involves the smart dispatch of energy storage, O&M, and user-side power management to maximize solar energy efficiency. We developed a smart home energy management system that perfectly integrates solar+storage, EV and IoT devices. It's a one-stop solution that combines high-efficiency power generation, safe power storage, smart power consumption, real-time energy control, and centralized management of energy information. The technologies of Big Data and AI deep-learning are used to support the prediction of energy generation and consumption, and to enhance the smart control functions. That creates a complete ecosystem for a green smart home.

So what is next for innovation in inverter technology?

Currently, the electrical and electronic technologies of PV inverters have become increasingly mature. I believe that the directions for future innovation in this space will mainly come from several arenas. First, technological innovations and upgrades will be at the component and module level, and applied for the optimization of PV inverters. Second will be at the system application level – focused on PV system safety such as AFCI protection and RSD on the one hand, and smart O&M on the other – especially innovations built upon IoT and Big Data – which redefines application for conventional energy industries. And lastly, the trend of interconnections between distributed generation solar PV systems and smart dispatch, basically the establishment of an 'energy internet.' pv

A Decade of Wins

Since its establishment in 2010, Growatt has become one of the world's leading inverter manufacturers in the distributed generation (DG) marketplace. The global inverter manufacturer has focused its strengths on nurturing the residential, commercial and industrial market segments – and has received a plethora of awards and recognitions for its contributions to quality and innovation in the solar industry.



for DG Solar

2016

- #1 residential PV inverter brand in China, holding national top market position to-date

2017

- Doubled its sales revenue for the second consecutive year, and achieved Top 10 global inverter supplier, per IHS Markit
- Global inverter shipment exceeded one million units
- Launched company's first smart home energy management system

2018

- #3 global single-phase inverter supplier: IHS Markit
- Established a joint research laboratory with ON Semiconductor
- Launched MAX 50–80kW inverter series and received All Quality Matters Award by TÜV Rheinland

2019

- Established joint research center with National Electric Power Conversion and Control (NEPCC) with China's Ministry of Science and Technology
- Launched GroHome, second smart home energy management system
- Ranked in top 10 global PV inverter suppliers: IHS Markit, Wood Mackenzie
- #3 global single-phase inverter supplier: IHS Markit
- #5 global supplier of three-phase string inverters: IHS Markit

2020

- Established new manufacturing plant with 10GW annual production capacity
- Launched full product line of X Generation PV inverters
- Launched 175–253kW 1500V string PV inverter for utility-scale solar plants

Stringing up a success story

India-based Navalakha Translines chose Growatt's string inverters for its 6 MW ground mounted plant in the Osmanabad district of Maharashtra in 2019, at a time when prices of string inverters were prohibitive for ground mounted solar PV plants. But the decision paid off, as the inverters with smart cooling are a great fit for the uneven terrain witnessing temperatures as high as 45 degrees Celsius.

A high irradiation level makes the Osmanabad district of Maharashtra, India the preferred choice for setting up a solar PV plant. However, the region poses challenges of uneven terrain and high ambient temperatures, which could impact the modules' power output and inverter performance. Keeping these challenges in mind, Navalakha Translines decided to install Growatt's string inverters with auto cooling for its 6 MW ground mounted solar PV system.

The plant is providing significant power generation with 30,000 kWh of daily output, across 300 sunny days each year. Navalakha Translines feeds all power generated into the grid, and sells energy to different organizations under open access.

Growatt MAX string inverters installed at a project in Maharashtra, India.

"Dependability, quality, easy installation, after-sales service and presence in the market—all these points work in favor of Growatt," said Navalakha Translines founder Satendra Navalahka.

Another advantage of Growatt inverters is their integrated cloud-based communication platform system. This allows the plant owner to see instantaneous output of each inverter on his mobile, and in the case of error, call site engineers to check a particularly weak inverter's performance in comparison to others.

Why string?

Based on his experience with Growatt inverters, Satendra Navalahka recommends the use string inverters, when cost comparable with central inverters.

"One advantage with string inverters is that civil work is reduced. You can complete installation and start generation within three months, as compared to central inverters which require significant work, such as setting up a room, etc." says Navalahka. "Further, the failure and maintenance loss is much higher for centralized inverters than string inverters. Even if a string inverter fails, you don't lose much generation."

The company founder says that after-sales service and repair of string inverters is also easier than central inverters, which supported Navalakha Translines' decision to choose string inverters for the plant.

How self-cooling works

To manage the temperature of internal components, the cooling system needs to be efficient. As ambient temperatures in Osmanabad reach up to 45 degrees Celsius during summers, the inverter temperature would be higher than that as all the insulated-gate bipolar transistors (IGBTs), or internal components which convert DC into AC, are working continuously for 10-12 hours per day.

The Navalakha project specified 84 Growatt MAX 60 kW PV inverters. The inverters come with a self-cooling mechanism, equipped with IP67 fans to avoid overheating. Further, if you place these

Photos: Growatt

inverters in an outdoor environment, they are inherently protected from the elements, such as dust and rain.

"All these fans work at a preset temperature. This means the first fan will start only when the temperature of the inverter crosses a particular level, also the fan speed will increase with the temperature rise. The second fan will start if the temperature increases beyond a threshold level," explains Shantanu Sirsath, Growatt's technical head for India. "We have set two threshold levels for the fans to minimize the consumption from the DC-source panels."

He added that the lifespan of Growatt inverters covers around 25 years under favorable conditions, which is equivalent to the lifetime of the solar plant. These values were then factored into their design decisions for the project.

Cloud-based communications

For large-scale projects such as the Maharashtra 6 MW plant, Growatt provides a special monitoring device called Shinemaster. With this single device, one can monitor 32 inverters through RS485 connection. In the case of Navalakha Translines' system, the device is being used to monitor 18 inverters.

Shinemaster collects all the data of individual inverters and sends it to a server. A special login account allows for Satendra Navalakha to monitor the performance of his whole plant as well as that of individual inverters from his office or any remote location around the world. If there is an error alarm, it will be displayed on the portal. Directly from the monitoring page, it is possible for system owners to determine which particular inverter is giving what sort of error.

"It's easy for our service engineer to ascertain whether the problem is due to voltage issues, hardware failure, or something else," says Growatt's Sirsath, adding "The next preventive action will be that our engineer visits the site and repairs the inverter or provides a replacement, if required."

Remote service possible

The Growatt portal also provides remote online service, for example, remote updates to inverter and datalogger firmware, preset inverter parameters etc. According to Growatt service engineer experience, more than 60% of service issues could be solved online, which obviously reduced on-site service time and cost, and is much more convenient for customers.

The whole package

Looking forward, Navalakha Translines will use Growatt's 253 kW string inverters for its next plant of 10 MW, also in Maharashtra. The company says it is also developing a new plant in Himachal Pradesh, that will also specify Growatt's inverters.

"Growatt's presence in India, and their capability to offer different capacities of inverters, continuous research and development, good after-sales service – and above all else – a good combination of features with price advantage is why we prefer Growatt inverters," said Navalakha.

"The failure and maintenance loss is much higher for centralized inverters than string inverters. Even if a string inverter fails, you don't lose much generation."

Off-grid Brazil: extending beyond isolated communities

The Brazilian power grid reaches approximately 99% of the country's population. To connect the remaining 1% has been challenging – often located in isolated communities of regions that are difficult to reach. With increasing global adoption of solar+storage, and significant price drops across the two technologies over the past decade, the solution is showing promise for the remote Brazilian market. Solar+storage is becoming a more competitive solution than its most popular alternative – diesel – to supply the needed power for off-grid communities. And now, even grid-connected residential properties are opting for independence.

Looking for diversification in its product and solution offerings in Brazil, Growatt has set its eyes on supporting the remote distributed generation marketplace. The fast-growth inverter manufacturer recently won a contract for an isolated solar+storage project located in Minuaçu, Goiás, and is looking to expand the new business model in this arena. The new 7 kW off-grid solar PV system will supply power for a basic health unit in Avacanoeiro, an indigenous village of Brazil.

Photos: Growatt

"This project is of great importance as it will not only guarantee energy for care in the indigenous village, but it will also provide for the conservation of refrigerated medicines and vaccines," says Talyson Alves, Growatt's marketing manager in Brazil.

Supported by a carport structure used by the National Indigenous Foundation, the PV project consists of 24 335W solar photovoltaic modules. Three of them will be used to power a pumping system, and the remaining 21 make up the off-grid solar PV project coupled with Lithium Iron Phosphate (LFP) battery technology. The system is supported by a 5 KVA Growatt Inverter, 14.4 kWh battery and 100 Amp Growatt sine wave Charger Controller

Market growth potential

Brazil's state-owned research firm for the energy sector, EPE, has been supporting the government with studies for sustainable development of the country's energy infrastructure. According to the latest data available from EPE, Brazil had 270 communities isolated from the power grid, accounting for approximately three million people without power at the end of 2018. With more than 209 million people residing in Brazil, nearly 1.5% of the country's population have been without grid access. Approximately 265 power plants have been supplying these localities, with a total capacity of 1.16 GW, primarily from thermal plants consuming diesel.

Specifically, it is the logistics needed to continually replenish these plants with the fuel that may turn solar+storage into a competitive option for the Brazilian off-grid market. At least the federal government seems to think so. In March, the Energy and Mines Ministry (MME) announced that approximately 72,000 families in the Amazon region plus the State of Mato Grosso, the "legal Amazonia," will have access to energy through solar PV systems. This should happen over the next 10 years, supported by a total projected invest-

Rooftop PV generators, such as Moisés da Silva, are opting to install battery storage systems and disconnect from Brazil's grid network to save money on their high electric bills.

ment of R$ 2.4 billion.

Late last year, the MME's general coordinator of social policy development, Paulo Cerqueira, announced an expansion of the Luz para Todos ("Power for All") program. The federal initiative that was established in 2003 to promote the universalization of power supply in the country has already served 3.5-million families, with R$ 20 billion invested in off-grid. By 2022, it is estimated that the program will serve more than 400,000 additional families in rural regions.

A competitive solution

Solar+storage in Brazil is not solely limited to isolated communities for off-grid support however, and Growatt is planning to offer others with a competitive solution. "It will also fit in very well commercially, for example, for a fishmonger in a region where service is not very reliable," says Alves. That is, in cases where continuous power supply is critical for consumers, they may also need backup power when the local grid suffers from regular interruptions. While this is usually done with a diesel generator, solar+storage offers competitive advantages, such as mitigated fuel and logistics costs. And Growatt believes that its inverter's remote monitoring system could be a key differential.

"A decisive point to determine the last contract in Minuaçu was our Online Smart Service technology, which allows the operator to diagnose and solve problems remotely in a quick and efficient manner," says Alves. He recognizes that the installation of the solar+storage system can still be more expensive than that of a diesel generator, but in the long run, without the purchasing and logistics of fuel, the solution can be advantageous.

Rooftop solar+storage

Recently, Growatt has also begun working with residential customers. Moisés da Silva, a homeowner that could be connected to the grid's power supply, chose to install his own 6 kW solar+storage system. The client was motivated by high tariff prices (R$ 0.52/kWh) for residential consumers in his state, Espírito Santo. The newly installed system runs with two SPF 3000 LVM inverters of 120V, in parallel, split-phase allowing to connect 220V devices.

And Moisés' project has been broadcasted widely. On the customer's Sol na Placa ("Sun on the Panel"), YouTube channel, he has shared his personal experience going solar with a reach of 45,000 subscribers. The client frequently comments, "Solar energy is not just for rich people."

The second inverter in Moisés' system was donated by Growatt after he spontaneously mentioned the company in one of his videos. With the paralleled configuration, Moisés was able to install an electric shower in his house.

"I have seen a growing range of people who install off-grid systems, even when the grid is available," says Alves. "Power is expensive, so they cut off their connection from the network and save money." Off-grid systems, he says with enthusiasm, are now becoming an attractive option to a wider range of consumers. pv

> *"In cases where continuous power supply is critical for consumers, they may also need backup power when the grid suffers from regular interruptions"*

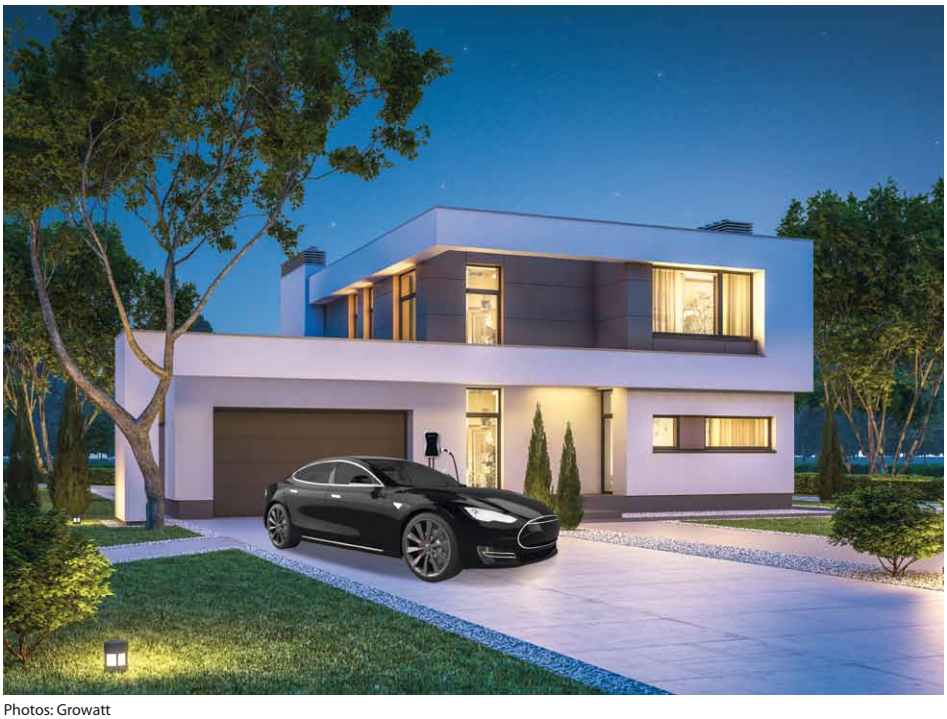
The smart home

Imagine an energy system where power generation is achieved through a diverse and decentralized network of energy units, such as your rooftop solar panels, that are monitored intelligently and the grid is able to manage supply and demand in real-time fashion. In this next energy era, the electric utilities do not generate their primarily revenues from moving electrons – but instead, by gathering and managing data – offering services rather than power. The vision of this futuristic energy system is not far from reality – and definitely provides a direction of travel for the energy industry.

Residential and commercial energy unit generators stand in the epicentre of the new era of communications-enabled girds and the two-way power flows management. The emerging question for households and businesses alike is where the new energy future stands.

Today, this trend is enforced by the current regulatory response to lowering solar PV system costs. Where distributed energy generation was once mandated by state support schemes (most notably the feed-in tariff remuneration mechanism that has provided a stable income to rooftop PV owners for all generated electricity), nowadays regulators are mandating a market-based approach.

Under the new market approach, distributed energy resource (DER) projects are remunerated solely for the amount of electricity exported onto the grid, usually for a very low export rate. But the latter is not always guaranteed. For example, many countries apply self-consumption schemes, which allow households to generate solar energy for their own consumption but not remunerating any potential exporting power to the grid. The more that self-generated solar power is self-consumed, the more a household or small business solar PV system becomes profitable. So, what is the most optimal and profitable way to use solar power? And how can producers consume more of the self-generated solar energy?



Photos: Growatt

Matching operations with information technology

Energy analysts agree that the answer to these questions is going to involve a more integrated, smart offering that includes solar systems combined with energy storage, electric vehicles (EV) charging, heating, demand response, and energy efficiency.

The UK's Renewable Energy Association (REA) is actively campaigning "to develop decentralized systems that include more than just solar power systems, energy storage, and EVs," says Frank Gordon, head of policy at REA. "We have called for more renewable and clean technologies to be included in the Future Homes Standard [a policy package] linking up not only power and transport, but also heat from 2025."

Growatt's GroHome solution is doing exactly this: It integrates a solar PV energy

in focus

system with energy storage, EV chargers, water heaters, and internet-of-things (IoT) devices – such as a smart plug, thermostats, and air-conditioning units.

During optimal sunlight hours, the solar energy will be consumed by the household appliances automatically through IoT devices. Sometimes the surplus solar energy will not be consumed fully, and in these cases, it can be stored into the battery storage system for consumption at a later time. This power could even be transferred into thermal energy as usable heat, to increase the rate of self-consumption considerably.

> *"Garden lights can be turned off automatically at 6AM when your alarm rings"*

The GroHome solution brings the role of distributed generation to the forefront of the energy transition. It bridges together all the hardware – such as solar modules, inverters, battery storage, and smart appliances devices – and the software, such as smart monitoring apps. GroHome integrates the hardware and software, matching operational efficiency with the information technology in a unified, consumer-friendly system. Growatt achieves this through remote controls, smart energy management, multi-zone controls and a hotkey app.

The GroHome solution

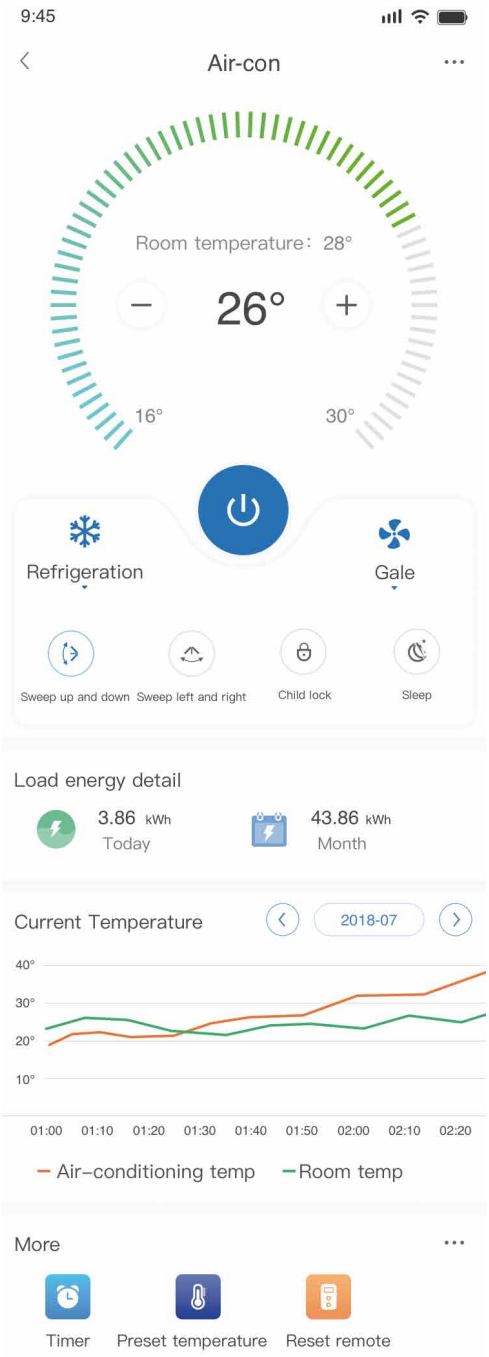
Homeowners are able to remotely control, turning on and off, the household appliances linked to the GroHome system. The smart energy management system provides GroHome owners the opportunity to advance smarter living. For example, garden lights can be turned off automatically at 6AM when your alarm rings. The GroHome multi-zone control function allows for customers to smartly monitor the different areas of a house, establishing a customized energy model for each area, to employ the most intelligent energy saving strategy. And lastly, ShinePhone, the Growatt hotkey app, gathers all previously logged functions in gadgets and allows the app user to control the household appliances with a single touch.

A complex series of IoT devices reinforces these processes to make the GroHome smart solution possible. Compared with a traditional switch, the wireless GroPlug and GroPanel remotely calculate power consumption of the connected appliances. Similarly, the GroThermostat is used to control the temperature of the floor or water heating system, to keep a room and household at comfortable temperatures whilst minimizing energy use. Lastly, Air-condition Mate, provides remote control opportunities for air conditioners and even a power consumption analysis.

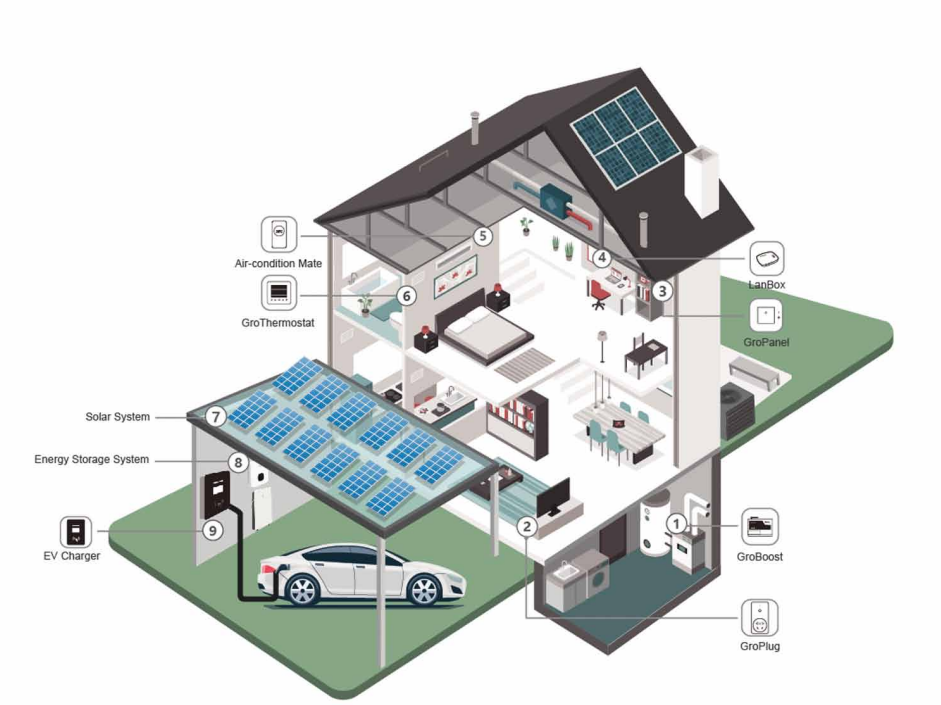
All in all, the GroHome solution provides homeowners a combination of intelligent solar energy generation with energy efficiency – increasing a household's rate of PV power self-consumption, while reducing the household's overall energy consumption – to achieve 100% green energy powering their homes.

Fully clean: moving to 100%

Growatt puts forth a key strategy with its GroHome system: To link solar energy



Growatt's ShinePhone app gathers all previously logged functions and provides user control of household appliances with a single touch.



Growatt models the PV home of the future with its new solutions bridging together hardware and software for a more efficient household with 100% clean energy and maximum self-consumption.

with household IoT devices to support a zero export model of solar power to the grid. When solar panels generate more energy that a household is consuming at a given moment in time, GroHome will automatically activate a homeowner's smart IoT appliances to avoid unnecessary export of self-generated power to the grid and instead use the extra power to charge the home's appliances. This strategically reduces electricity bills and leads to a greener household.

> *"During optimal sunlight hours, the energy will be consumed by household appliances automatically through IoT devices"*

Savings and environmental benefits can be further optimized with GroHome's software if battery energy storage, EV charging, and thermal energy storage are also employed alongside the PV system. Batteries store surplus power during the day and make it available for consumption at night, and EVs can support the green mode transportation and also be used as an additional larger storage option. Additionally, thermal storage heaters such as electric boilers also typically have enough capacity to store a portion of surplus solar energy as usable heat.

Bringing it together

To take a practical example, when a battery system has been fully charged during sunlight hours and the solar panels continue generating energy, instead of exporting the surplus power to the grid for a low export tariff or even for free, a GroPlug will be activated automatically to power or control pumping water to the swimming pool, the washing machine, or other household appliances. At a later time, if solar power is insufficient, the battery system will discharge to supply power for loads. As a result, parts of consumption could be shifted from evening times to hours of sunlight.

Moreover GroBoost, one of GroHome's processes, can also convert the surplus solar energy to usable heat. While a homeowner would typically set up the timer of the electric boiler to be powered during night tariffs for saving electricity, GroBoost can intelligently control heating elements to provide hot water in boilers. In the presence of an EV charger, the GroHome system can utilize the surplus energy to charge the EV any time of the day. All this activity, with both solar energy storage and IoT device usage, is graphically demonstrated via the ShinePhone app, depicting the energy flows, clear energy data, and the status of GroHome appliances.

What does this mean for the future of rooftop PV? The forecast is looking smart. Communities around the world have begun exchanging and trading electricity in a peer-to-peer mode. As the world's energy systems become more decentralized, and export tariffs become lower, homeowners are stepping up in their power. And GroHome households will be better equipped to reap the benefits of the digital future and trading patterns. pv

Quality matters: Growatt's five-step system

In 2018, Growatt's new MAX series 80 kW inverter became the only commercial and industrial (C&I) inverter to receive the 'All Quality Matters' award from TÜV Rheinland. The MAX 50-100K is the company's latest C&I flagship model to be launched by the Shenzhen-based manufacturer. With a maximum efficiency of up to 99%, the new solution offers 6 to 7 MPPTs. TÜV Rheinland's prestigious award begs the question: How was Growatt able to reach this high level of quality, reliability and performance?

Photos: Growatt

Growatt's company culture is based on two principles: 'product quality is the company's lifeline' and 'reliability comes first.' The company leans on these principles for providing the foundation for its success in the more than 100 countries where Growatt's products have been installed. The manufacturer shipped approximately 5 GW of products in 2019, and is set to open a new factory in Huizhou near Shenzhen this year with an annual production capacity of 10 GW.

Five-step quality system

Ensuring quality and reliability at such an expanded scale is no small chore. To achieve the level of success at such large scale, the company says it relies on five quality steps, which together provide a rigorous quality framework. As the illustration on page 16 shows, the first step involves design engineering. This is followed by components engineering, which involve sophisticated lab tools such as metallographic microscopes and stereo microscopes to screen for component deficiencies. The next step, shown in green in the illustration, involves testing engineering. The company's new products not only pass the company's rigorous testing and verification department, but also go through more than 20 certification systems adopted by various countries in the world.

The final two steps include environment and reliability engineering and manufacturing engineering inside the factory. Since PV inverters must perform reliably for many years, long-term reliability tests validate Growatt's inverters continue to function in a reliable manner even in challenging environments. The final quality step in the five step program is manufacturing engineering, where state-of-the-art production facilities play an important part in ensuring the consistent quality of Growatt's products. Based on serial number, the manufacturer can identify the specific components and production steps that went into each product.

A special class of electronics

In some ways, PV inverters are similar to conventional electrical home appliances. However, a fundamental difference is that when the inverter is running, with high current, high voltage, and high temperatures, the power is tens to hundreds of times that of typical home appliances. PV inverters frequently are not installed in comfortable indoor temperatures, and regularly face harsh environments with

> *"Based on serial number, the manufacturer can identify the specific components and production steps that went into each product"*

Growatt's five step quality system

Design engineering	Components engineering	Testing engineering	Environment and reliability engineering	Manufacturing engineering
• Circuit topology simulation, detailed circuit design and calculation, PCB layout, software design • Structural design, thermal simulation • Unit test, integration test and system test	• Component selection and application • New component / process introduction certification • Component stress derating, design life assessment • High-risk component reliability assessment and testing	• Structural test (heating flow, air tightness, waterproof, mechanical test) • Stress test, functional performance test • Fault injection test • Certification test	• Environmental test, reliability test, HALT • Reliability prediction, DFMEA • Application reliability test (empirical verification) • Long-term reliability test, ALT accelerated life test	• Fully automatic production, testing and aging control system, 100% aging test • Tire 1 Processing Auxiliary Material (Solder Paste, Tin Wire) • Fully automatic three-proof paint spray dryin production line, 100% paint protection • ORT / LLT (production online test, long life test)

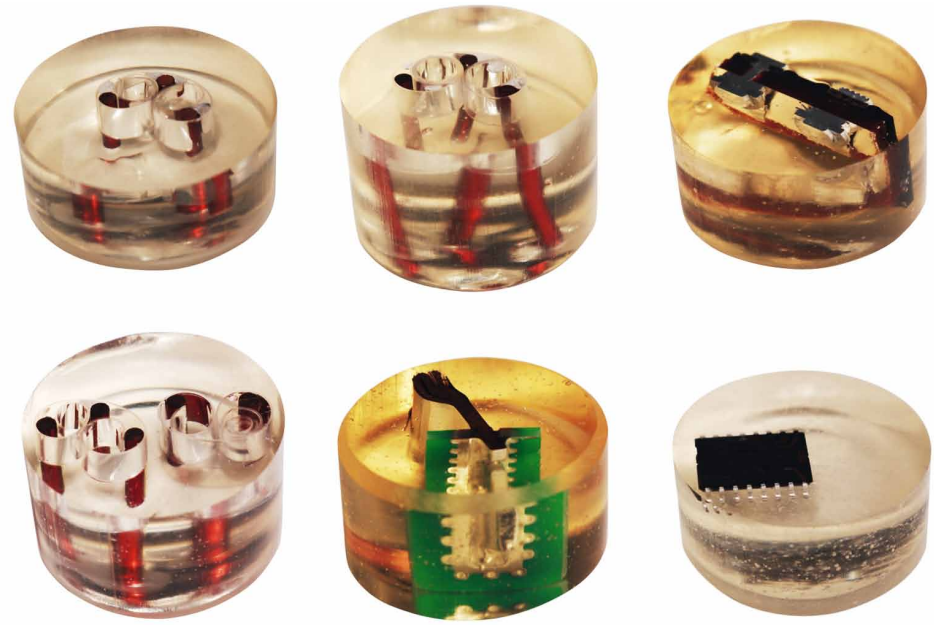
Source: Growatt

temperature fluctuations, humidity, and extreme weather conditions – challenging both quality and reliability of the electronic equipment. Over the past 10 years, Growatt has made this challenge its priority.

DPA testing

As part of Growatt's full quality control process, the company operates outdoor testing sites, where new products can be put to the test in harsh weather conditions. In the case of the MAX 50-100K C&I inverter model awarded with TÜV Rheinland's 'All Quality Matters' seal, outdoor testing revealed issues with the freewheeling diode in the boost circuit's power module, whereby the diode had been damaged in severe weather conditions with thunderstorms. The diode fault was triggered by a mismatch between the inrush current and the rated current of the component. This conclusion was found through the company's components engineering quality step, whereby Growatt's special components reliability department performs a wide range of tests on individual inverter components. For example, in the case of relays, these tests include X-Ray inspection, microscope observation, and DPA (destructive physical analysis) testing. Growatt is one of only several inverter manufacturers in the world to use DPA analysis technology to aid in product design. Both the metallographic and stereo microscope are essential tools in performing such analysis. In the case of the MAX 50-100K it was DPA analysis that revealed the module diode problem in the boost circuit, and then helped the R&D team to determine the best solution, followed by subsequent tests to verify that the problem had been thoroughly solved.

Growatt use DPA technology to aid in product design and failure case analysis. This picture shows component samples for DPA analysis, including MLCC, resistors, transistors, diodes, and chips.



Better O&M, and the integration of storage

Growatt's 'reliability comes first' mantra also serves to reduce O&M costs out in the field. With rapidly declining costs of battery energy storage, PV systems are increasingly equipped to store clean energy as part of the distributed energy resource system. The company says that by offering products and solutions with a high degree of quality and reliability, it is able to reduce the number of O&M truck rolls to the customer site, thereby further reducing the levelized cost of energy (LCOE) of the installed system.

As solar+storage systems become increasingly popular, Growatt forecasts that approximately 30 percent of the company's shipments will be in the battery storage category this year. Sourcing battery cells and modules from top-tier specialist manufacturers, Growatt then adds further capabilities to the battery product, including the battery management system and the housing of the battery unit. With the company's five step quality system integrated firmly in place, we can expect battery technology from Growatt to exhibit the same level of performance and stability the industry has come to value in the ten years the manufacturer has supplied the world with in its wide range of on- and off-grid inverters.

Monitoring: Driving reliability and O&M efficiency

Photovoltaic inverter monitoring has emerged as the primary tool for optimizing solar plant performance, and additionally, simplifying the operations and maintenance of these assets.

Inverter monitoring and control systems are using increasingly sophisticated analysis of sensor data to remotely optimize the integrated levelized cost of energy (LCOE) across different manufacturers' inverters within a single plant. This data is used to holistically control plant and portfolio generation, while planning O&M in the most cost-effective manner.

These more advanced inverter monitoring systems are in greater demand today than ever to assure the resilience of PV plants due to both the new surge of power outages, along with the historic problem of random surges in power demand. These problems can cost asset owners millions of dollars per day in lost revenue without advanced monitoring, opines Pritil Gunjan, a senior research analyst at Navigant Research.

The demand for such inverter monitoring technology is increasing rapidly. The global market for renewable energy monitoring and control solutions is expected to reach an estimated $82.9 billion in cumulative revenue between 2019 and 2028, reflecting a compound annual growth rate of 12.5%, according to a February report from Navigant.

Driving features of the inverter monitoring systems are one-click smart I-V curve diagnosis across entire plants, grid-side failure function recording, and online inverter support service with 24/7 fast

Solar inverters are now working as powerful O&M tools with one-click remote diagnosis reporting.

Photo: Growatt

response. At the same time, these monitoring systems are equipped to analyze both 600 V and 1,500 V operations, as the industry migrates to higher voltages.

Advanced algorithmic data analytics, robotics, and machine learning have made inverter monitoring solutions both more intelligent and more economically attractive, Gunjan writes.

Measuring more variables

I-V curve diagnostics are said by Growatt to be the most useful function in inverter monitoring systems, using algorithms with a one-click diagnosis to helps to check performance of the entire system, and locate faults. "With string monitoring and I-V curve scanning, it's easier to recognize a fault in a string or a low performance string," says Lucas Wu, European product manager for Growatt.

The most advanced inverter monitoring systems also enable total harmonic distortion voltage (THDv), ISO and grid line impedance analysis, and the wave record of the inverter. "The THDv and grid voltage waveform can also help us to know the grid's condition. The DC isolation and AC line impedance show the system condition on the DC/AC side to let us know when, where, and why there may be a fault," says Wu. "Further, the fault wave form record function is a special tool for remote diagnostics when complex problems occur." Growatt engineers are testing and analyzing systems remotely, without on-site visits, he adds.

As more electronics move into inverters and away from external controller modules, the data provided by the inverters become more granular in shorter periods of time, allowing specific functional analysis within seconds, rather than minutes or hourly tracking that earlier systems relied upon. With such granularity, the need for advanced communications capabilities arises, so that data is transmitted wirelessly to the web, which also permits remote decision-making.

Analysis is also moving toward individual inverters, rather than aggregate plant performance and failure monitoring, with the use of variable set point triggers that capture records used in monitoring and decision-making. "Customers want to divide their plants into subarrays, so that they can manage their generation by plant, by subarray, or by device view," says Wu.

"With such granularity, the need for advanced communications capabilities arises"

Global support platforms

Inverter monitoring systems have evolved to the point that they are plant-location agnostic, with Internet-based access by customers or O&M operators anywhere in the world. These analysis and reporting systems also have become responsive 24/7, so that an asset portfolio manager can have a single, seamless view of plant performance across the globe.

"Our customers ask questions directly through our operating system which then becomes a fast-response work order dispatched to our service engineering teams in Europe and in China, no matter what the time," confirms Wu. "This enables a faster response mechanism with a powerful dispatch function." The company has more than a dozen offices and warehouses worldwide.

The size of an inverter monitoring system is also crucial to providing 24/7 response. Some inverter monitoring system providers are merely regional or national, which limits aggregate intelligence across geographies. Growatt has the reach to provide a global solution, having shipped more than 5 GW of inverters in 2019 to make it the world's eighth-largest global inverter supplier, Wu points out.

Re-tooling inverter monitoring

Among the market drivers that affect the adoption of new, more advanced monitoring and control solutions are renewable assets that are nearing the end of their warranty agreements, according to Navigant's Gunjan. "Achieving cost reductions while improving efficiency is one of the key strategic priorities for all asset operators."

Longer-term O&M service contracts that carry performance guarantees help asset owners calculate their return on investment, and to plan for future O&M repairs. These guarantees also help define grey areas of O&M projections in bankability studies required for new developments.

However, new global disruption in the PV supply chain caused by Covid-19 now also poses a threat to the response time for PV repair equipment, which can increase downtime, particularly for off-grid or remote on-grid locations. Thus O&M service agreements that provide strategic stockpiles of equipment that can be used for rapid retrofitting deployment should become more attractive.

Australia: Growth in capacity and consumer sophistication

With more than 2 GW of installed capacity in 2019, Australia's rooftop PV market is booming and is expected to continue its record-breaking run this year. As distributed generation (DG) continues to grow in strength, Lily Zhou, COO of Sunterra, talks about the country's evolving market landscape, and customer's growing preference for top-notch products and services when choosing equipment.

What does a strong rooftop PV market mean for Sunterra as an established installer in the Australian residential and C&I sector?

The Australian rooftop PV market grew significantly in 2019, and this growth is expected to continue this year. Actually, one could say that Australia's rooftop PV is one of the most stable markets in the world. A major factor behind the stable solar industry is a supportive government policy called the small-scale renewable energy scheme (SRES), which provides incentives for residential and commercial users. In addition, the SRES creates jobs and demand in the market and lowers the threshold for system providers to enter the market, which contributes to a stable and fast-growing solar industry in Australia.

We at Sunterra have enjoyed the benefits of the supportive government policy and the overall industry environment. We do not need to worry about creating an industry because it is already developed and stable. Instead, we can focus more on business operations and on sourcing better products and delivering better services to our customers.

Contradicting rooftop PV installation rates, behind-the-meter battery storage deployment has been sluggish. What have you noticed in terms of sales trends and overall demand for batteries?

Indeed, but these are two consecutive stages of distributed power generation, and the development of the energy storage market is supposed to take place after solar PV. Right now, battery storage is at the same stage solar PV was ten years ago in Australia. People still hesitate to install batteries nowadays mainly because of the return on investment. Since they are still relatively expensive, people need to pay a fair bit upfront to get a battery installed. However, we can clearly see that battery storage is changing from a concept to a standard home appliance. This is especially the case in South Australia, where the state government has the Home Battery Scheme in place that significantly cuts the upfront costs.

Manufacturing costs continue to fall, and this will enable more and more consumers to opt for batteries even without special rebates. We have already observed a considerable increase in solar+storage demand in other states as well, for example, in Western Australia, where the local government does not have a battery scheme in place.

Sunterra is operating across the country. What state-to-state market specificities are the most pronounced?

The Australian solar market is exciting as it varies from one state to another in terms of market features. The Western Australia market is the most competitive, both in terms of the number of system providers and prices. In South Australia, the power prices are the highest in the country, so the solar market is the most saturated one, with around 30% of rooftops already with PV systems. Due to the high level of solar penetration, the power network is not really stable, and this has contributed to the deployment of the state government's home battery scheme. In Victoria, the state government offers an additional solar rebate – which initially raised market demand significantly. However, very strict safety requirements were introduced at a later stage which has led to much higher installation costs. So, solar PV providers in Victoria, Sunterra included, are trying to digest the policy changes and adjust their operations. New South Wales and Queensland make up the largest proportion of the Australian solar industry, the markets are very healthy and competition is high.

What kind of qualities are customers searching for in PV equipment?

Customers are making use of all kinds of information channels to research PV equipment. So what they do is compare different brands in terms of market history, product durability, quality, reliability, and even other factors, such as customer service or warranty claim

Lily Zhou is the COO of Sunterra, a leading Australian project developer in the rooftop solar market.

Photo: Dillon Williams

Solar+storage is becoming more prominent in the Australian DG market. This residential system installed in South Australia by Sunterra's partner, Dillon Williams, opted for Growatt products.

experiences. Therefore, our selection of supply partners is reflecting our customer preferences. We look for high efficiency, better quality, and larger brand impact.

It is also worth mentioning that customers tend to have additional preferences when it comes to the selection of inverters. They stress the importance of the external design, and require that inverters have multiple functions. For example, they want inverters that are battery-ready and can be remotely monitored so they can see on their phones and laptops how the system is performing. Customers also stress that good inverters have an off-grid mode available.

What are Sunterra's quality requirements when choosing its partners?

At Sunterra, we are very careful when choosing product suppliers. We believe that a long-term business relationship really counts, and we would only select those suppliers who continue to deliver reliable products and services. For example, our major solar panel partners are Jinko and Longi, as well as Japanese high-efficiency PV panel manufacturer Leapton. In terms of inverters, we mainly partner with Growatt, which offers high-efficiency products and continues to innovate. We opted for Growatt after reviewing lots of different inverter brands. Actually, Growatt solar inverters have been in the Australian solar market for ten years now, and they are well-known as quality, reliable inverters. Recently, Growatt won the award called Top Brand PV Seal in Australia.

Growatt is one of your long-standing partners offering its on-grid, off-grid, and storage inverters for residential and commercial applications and batteries. What advantages have you found in their products?

Growatt has such a comprehensive product line that whenever we have a different customer demand, we can always find the particular product to supply them. On-grid inverters are the most demanded among our residential and C&I customers, while off-grid inverters are mostly used in rural areas. We have also seen a rapid increase in demand for storage-ready inverters.

Growatt offers an online platform that allows its engineers to notice a performance issue even before the customer, which means they can send their technicians proactively before the customer would even report a faulty unit. This brings the customer experience to the next level. Growatt offers high-standard product support. In Australia they have local engineers and support teams who provide useful system design information for us at the sale stage. They offer technical support to our installers. They also offer excellent customer service after installation whenever customers have an issue with their inverters or batteries. Therefore, at Sunterra, everyone from installers and sales to customer care officers and our customers, are very confident with Growatt inverters and their team.

> *"The next trend will be driven by the consumer's energy consumption habits"*

What do you believe are the next trends in residential and C&I solar equipment in Australia?

The next trend will be driven by the consumer's energy consumption habits that continue to evolve. People will continue to move to solar, but more will be accompanied by storage. In terms of solar equipment, PV panels will have increasingly higher efficiencies, and more and more inverters will have a battery-ready mode and blackout protection. pv

Local knowledge, global growth

Through its key regional partner Omnisun Srl, Growatt has offered its products to the Italian market since 2012 - making it one of the first Chinese inverter brands operating in the country. pv magazine caught up with Omnisun's chief technology officer, Giovanni Marino, to discuss Covid-19, reliable partners, new energy technologies, and his expectations for the Italian PV market.

Italy's PV market had been set for a comeback in 2020, do you still see this in the cards now?

In 2019, the market grew by almost 25%. The increase in quantity came mostly after cancellation of the anti-dumping laws on module imports from China. I think from that moment in Italy, quantities began to increase.

At the beginning of this year my forecast was for big growth in the commercial sector, from 20 to 200 kW, but now for 2020 I think that this market segment will be a bit delayed, maybe we have to wait for next year now. In 2020, there will still be an increase – before coronavirus I believed there would be around 30% growth. Residential is growing primarily because of falling system prices, it is more convenient to install solar. So I think small residential will see an increase even after the coronavirus effects. The increase in Italy will be around 15%, maybe 20%. For small commercial projects, I think after Covid-19 we will experience a little delay in order to bring the sector back to where it was before the pandemic.

Why did you choose to work with Growatt as an inverter supplier? What is the value of partnerships like this one to the industry?

We are the sole representative for Growatt in Italy. So it's a little bit of a different type of distribution. We are seeing good success in Italy, because we follow the commercial segment, we know the markets in Italy, and how to move in this kind of market. We started in 2012 with Growatt, and they are the oldest Chinese inverter brand in Italy. And we have increased volume 30% per year on average since 2012.

We don't sell any other inverter or storage system brand. Consider that in Italy, we are Omnisun, but over the past two years we pushed 'Growatt Italia' a lot on social media. Now, few people know of Omnisun, everybody knows Growatt Italia. And I'm very happy about this. We choose the products to sell for the market, we take care of advertising, strategy, everything. There has been a strong cooperation with Growatt here since 2012, we may be Growatt's oldest partner in Europe, so it's a special relationship. We come from the residential market, so our experience is there. And in the last few years we have moved into small commercial up to 100 kW, step by step increasing the range of Growatt products. We started with a range from 1 kW to 20 kW, now it is up to 80 kW. Enlarging the Growatt product range, we have started to work on other projects, in other areas of the market in Italy. We also started some years ago to work on larger plants, new installations, and also repowering old plants. Last year we replaced around 5 MW of inverters for older plants in the field.

"Storage is going to be more important for commercial as well as residential projects"

Photo: Omnisun srl

Giovanni Marino is the CTO of Italian solar distributor, Omnisun Srl.

What are the key requirements for inverters in the Italian market, what are customers particularly looking for?

After sales support. I think that this issue is maybe the most important one for PV products in Italy. For inverter and storage systems, the pre-sale and after sales support is the most important issue. This is one reason why Growatt is so well known in Italy.

We can provide support to all clients, from buyers to installers to EPCs. All can talk with us and know that here, in the center of Italy, there is a big team focused on helping them. We have a lot of installation partners who are very knowledgeable about our product, and we can arrive anywhere in Italy within 48 hours after the problem appears.

Growatt offers a good product with good features, and we could just sell it based on this, but one of the most important issues is the post-sale care. Installers that work with Growatt, my experience is that they never want to leave the partnership – maybe they buy others as well, but generally, who starts with Growatt continues with Growatt.

How do you see the role of energy storage in solar projects? Are most customers interested in combining PV with batteries nowadays?

We started with storage in 2016, and from that moment forward it has always increased. In Italy, Growatt represents roughly 20% of the storage market (residential, single phase). On the three phase of course there is not a huge market, residential is the main market, but storage is going to be more important for commercial as well as residential projects.

And I see Omnisun recently added an EV charger to its portfolio – how do you expect the market for this product to develop in the coming years?

The EV charger we are selling with Growatt. We are now pushing on the residential sector, and there is a big market for residential EV chargers. We have started with a residential Wallbox ranging from 3.6 to 22 kW. So in four sizes: 3.6, 7.2, 11 and 22 kW. We have also developed an app, and now I am working to create some partnership with a software company to meet the needs of clients in Italy. In the future, early next year, we will offer EV charging with each installation. Now we are focused on the Wallbox, and to perfect the app to work with a PV system. This will be linked to the Growatt monitoring platform, as right now the apps are completely different for the PV plant and the EV charger. We are working together to link the EV charger management to the monitoring PV platform in order to, if the client wants, manage their EV charging depending on the PV production. During this year we will provide the possibility to charge whenever there is enough power on the PV side.

Linking solar with energy storage and EV technologies

Solar is booming globally and as costs come down and the technology approaches grid-parity, historically based government incentive models and subsidies are changing –particularly for the distributed generation (DG) rooftop market. But new technologies and capabilities of other distributed energy resources (DERs), such as battery energy storage systems, electric vehicles (EVs), and other smart energy technologies, are stepping into position for a net-zero energy future – providing opportunity to advance beyond the power structures of the past.

Shifting tides of investment

Solar power has become a given element of the world's energy systems. However, investment trends are constantly changing thanks to evolving technologies, lower costs, and new remuneration policy mechanisms supporting energy development. Such a dominant trend is exemplified by the phase out of old, stable remuneration schemes, which are being replaced by more dynamic mechanisms that not only value the output of electricity generation but also the management and operation of the energy technology.

Britain and Germany, for example, are two of the top four solar PV and EV markets in Europe. The United Kingdom ended all residential solar PV subsidies on March 31, 2019, replacing the old feed-in tariff (FiT) policy with the so-called smart export guarantee (SEG) scheme. Launched January 2020, the new market-led scheme requires that all electricity suppliers with at least 150,000 retail electricity customers to offer at least one SEG tariff to new residential PV systems. The government does not prescribe the tariff rate, type, or duration, but the purchase tariff must offer a rate per kWh of export above zero at all times, thus providing income for households' surplus solar – differing from the past FiT system where generators were paid for all electricity they generated. The United Kingdom has approximately 3 GW of rooftop PV capacity installed for projects under 10 kW in size.

In Germany, 581 MW of solar capacity of projects up to 10 kW were added in 2019, while German market research institute EuPD Research recently surveyed more than 1,000 homeowners and found that 20% of them are actively making decisions to invest in solar PV. Survey participants said that they were motivated to invest in PV to reduce their electricity costs while contributing to the protection of the environment, but also to benefit from the state-guaranteed FiT.

Germany recently had a cap of 52 GW on the subsidy, which EuPD Research suggested would be reached by July 2020. Once the cap was hit, no new PV systems under 750 kW would be eligible for the subsidy. In May 2020, Germany's government abolished the photovoltaic cap and the country's residential and commercial PV sector is now waiting for the new measure to be implemented.

Other countries, such as Italy and Greece, replaced their FiT schemes many years ago with retail net metering (NEM) mechanisms that issue credits to electricity generators for the power they supply to the grid. Other countries, such as Portugal, have opted for self-consumption schemes that are similar to NEM policies but typically do not allow electricity credit transfers. Non-FiT mechanisms tend to reward residential solar generators based on market indicators, such as the electricity wholesale rate and retail prices in a given electricity market. In this expanding financial policy landscape, can solar PV systems develop in tandem with energy storage and EV technologies to enable the transition towards decarbonization?

Solar, storage and EVs: stronger together

"EVs, residential solar, and storage [can] absolutely go hand in hand," Frank Gordon, head of policy at the UK's Renewable Energy Association (REA) told **pv magazine**. As nations move away from fossil fuels and towards net-zero electricity systems, the energy structures we

> *"As nations move away from fossil fuels and towards net-zero electricity systems, the energy structures we have come to know will have to change"*

have come to know will have to change. We are moving away from the centralized form, revolving around a small number of power stations, towards a decentralized form with cities, towns, and houses acting as their own mini power stations. "EVs, residential solar and storage offer an efficient and cost-effective way of achieving this type of energy system," argued REA's Gordon.

A recent report from the US-based Institute for Energy Economics and Financial Analysis (IEEFA) states that "strong mutual benefits make these technologies even more disruptive together than in isolation." The IEEFA report, which focuses on Britain and Germany, argues that batteries and EVs can boost the economics of rooftop solar, by enabling households to use more of the solar power they generate, therefore increasing savings on their electricity bills. "These savings rise over time, as the cost of rooftop solar, batteries and EVs fall," says the IEEFA.

In Australia too, households have seized the opportunity to cut relatively high electricity bills with solar PV. According to a separate IEEFA report, the country's installed capacity was around 11 GW for distributed generation rooftop PV systems under 10 kW at the end of 2018. Government support for solar in Australia includes a solar FiT provided from retailers for energy exported to the grid and varies in price, both within and across territories in the country; and a capital expenditure rebate, which provides households with a rebate on a portion of the initial cost of a solar PV system. The IEFFA report projects that by as early as 2024, it will be cheaper for Australian households to invest in solar, storage, and an EV in combination, than in a solar system alone.

Regulatory and technological input

Calculating the payback period for either a PV-only system or a combination of PV, storage, and an EV depends on many factors. State support for either of these technologies is one of these factors, with the structure of the electricity market and grid charges certainly being crucial factors. But there have been setbacks.

The IEEFA calls for regulators to reform grid services and markets in a way that puts solar, storage, and EV technologies on a level playing field with conventional power generation. Smarter domestic tariffs that reward consumers for using off-peak power can further drive demand for all three technologies, as will smarter EV chargers that support grid stability. But the question that emerges is whether retailers will introduce such tariffs and services alone, or if they will need to be pushed by governments.

Apart from regulatory issues, another emerging question is whether the choice of hardware plays an increased role in the new era of dwindling public subsidies. The choice of inverters, says Ray Cheng, overseas marketing head at Growatt – is critical. "Our inverters and related Gro-Home smart management system have integrated the solar power system with storage, smart EV chargers, water heaters, and IoT devices to increase a household's rate of PV self-consumption," says Cheng. "Through smart energy management strategies, reducing the household's overall energy consumption, it is now possible to achieve 100% green energy to power your home."

The industry agrees that with lowered costs and dwindling state incentives for solar PV, energy digitization is paving the way forward. With the emergence of community microgrids and virtual power plants (VPPs) – the aggregation of assets such as solar PV, energy storage, and EVs on a cloud-based distributed power plant – combined with new technological megatrends such as 5G, IoT, and AI – will be the medium for the future energy transformation. pv

Solar PV systems coupled with battery storage and EV charging stations are becoming more common in the residential rooftop market.

Photo: Growatt

Inverter uptake in Australia: what's the verdict?

Australia is a booming market, for both solar and battery storage in the residential sector. This has inverter manufacturers optimizing their business models and support tools for developers. pv magazine met with Glen Morris, owner of SolarQuip, a company focused on renewable energy training, design, and installations to discuss the current state of the market – and the tools that are setting installers up for success.

How would you describe the rooftop market in Australia over the past year or so? It seems installation rates are at record highs.

Over the past few years, Australia has experienced high penetration of rooftop solar per capita. Small scale rooftop solar accelerated to 2.13 GW capacity in 2019. Combined total solar capacity, for both small scale and large scale projects, reached 3.3 GW in 2019. From 2017 until 2019, we have seen the growth rate for rooftop solar installations double.

I understand that array sizes and capacities are increasing in Australia. What are the sizes of residential systems being installed in 2020?

In Australia, most growth has been witnessed in a fringe of grid and small commercial systems. In 2019, the average PV system size was an astounding 7.6 kW. A similar trajectory can be forecasted for 2020. A system can be bigger than the needs of the household as per the Federal Government rebate based on PV capacity. Bigger systems offer faster payback periods and higher consumption of renewables. Australian roofs also have large surface areas and are not space constrained.

The residential market is established and mature in Australia. On the commercial and industrial (C&I) front it has taken a little longer to build momentum. What kind of development is occurring there?

For C&I, that can be attributed to low payback and lack of awareness opportunities. Large-scale generation certificates are generated after energy is produced and meter readings have to be submitted. With strong market for PPAs, the cost decreased from $80/certificate to $18/certificate. Now in 2020, the Large-scale Renewable Energy Scheme targets have been met and there is poor demand for these certificates. C&I systems are playing catchup to rooftop solar, but its trajectory is much faster.

For installation companies, it is quite a big step to move from smaller residential arrays to larger C&I systems. What are the challenges there?

Capacity, financial resources, connection agreements, network protection, and OHS (Occupational Health and Safety Act) issues such as heat, and physical access to rooftops for installers.

There can be technical challenges with larger C&I installations. How important is selecting the right inverters for the job?

Technical challenges, legal matters, poor contracts, poor quality equipment, and product failures. For example, while in-service, installers are liable to cater for expensive replacement of failed equipment. Having the right inverters for the job is critical, especially in quality and performance. For PPAs, efficiency of the inverter matters, even by a small margin.

Australia is considered one of the leading global markets for residential battery storage. I understand something approaching 300 MWh of residential storage systems were installed in Australia in 2019. What do you say is behind the decision for a homeowner to install a battery with their PV system?

For storage in Australia, no mandatory registration was required until the Distributed Energy Resources register was initiated by AEMO this year, in comparison to countries like the United States, where a permit needs to be issued, making tracking of battery storage installations easier. Australians are early adopters of technology and there is major interest in energy storage. It is a good place to learn and there are state-level government incentives for support such as in South Australia, Victoria, and New South Wales.

Glen Morris is a well-known figurehead in the Australian PV market for his company's training, design, and installation services.

Photo: Glen Morris

Photo: Growatt

A 300kW solar plant in Renmark, South Australia specifies Growatt inverters.

A homeowner may install battery storage for economic reasons, energy independence, or the need for backup power. Also, people are now choosing to stay in the same house longer, say roughly 10 years – which also coincides with the payback period of batteries. Batteries provide a strong backup, especially in bushfire and storm blackout situations.

How important is the provision of backup power for Australian households if they do decide to purchase a solar + storage system?

Very important, as it offers independence and security.

Even though prices are coming down, residential storage systems are still not cheap. What can homeowners do if they are installing rooftop PV today but may want to add storage at a later date?

Look for solar rebates, which is an upfront discount. Rebates vary with states also. Australia is at a good place when it comes to battery and inverter pricing, when compared to international markets such as the U.S.

Growatt's new XH inverter series is 'storage ready', how well does this cater to this situation?

The Growatt XH hybrid inverter can be installed as a pure solar only grid-connected inverter but has the ability to have energy storage added later. "Storage ready" should be on the minds of all customers when purchasing a solar inverter. Growatt as a mature manufacturer of inverters has a strong relationship with the Australian market and from my experience has good local and international support for their products.

Indeed, way back in 2011, the company had something like 23% residential market share in Australia. How would you say Growatt is perceived by installers in Australia?

Growatt is a mature company as it has been around for a decade. Globally, Germany was an early leader. But China is the leader now as it has narrowed down the market, and it is growing as the dominant supplier with high quality products which are reliable and affordable.

How important is local service in Australia? And how well do you think the Growatt team meets this need?

Very important, as there needs to be no delays in replacements, and supply chains must be efficient. Installers are under pressure. Sometimes they're unfamiliar with new products and with Growatt's new system, installers can video call while on-site and receive immediate local assistance. Support is also available while setting up software and metering, which is commissioned through the app, even when there isn't internet access. My experience with Growatt has been exemplary.

Brazil's solar promise trends toward DG

The Brazilian solar rooftop market has seen substantial growth in recent years, but with current uncertainty in policy development – the global PV industry is watching closely. Aldo Pereira Teixeira, founder and president of Aldo Solar, the largest distributor in the Brazilian market, sat down to discuss the company's secrets to success in a very large country, and the ever-evolving landscape for solar.

As a leading distributor in the Brazilian market, how does Aldo Solar maintain its competitiveness? What is your competitive advantage?

Aldo has been in the distribution market for 38 years and we have that in our DNA. We are committed to being a hub for the largest manufacturers in the world and have a deep knowledge and understanding of taxes in our country, which guarantees us and our partners tax security as another great advantage. Our key word is planning: we carefully monitor all movement of the local and global markets, organize ourselves in advance, and constantly review all scenarios. We believe in growing, and making our customers grow – together.

Distributed generation PV in Brazil has grown at exponential rates in recent years. How would the approval of a new less friendly regulation impact the pace of growth for Brazil?

The solar PV sector is developing in the country. And it should develop further, as it is a source of clean and sustainable energy, with proven benefits and the obvious trend in most developed countries of the world. At this stage, solar deserves encouragement and not a change in the rules. The approval of a potential new regulation will slow down the segment's expansion, job generation and make the ROI for end consumers more distant, possibly even making the project unfeasible in certain situations. If the current rules for distributed generation are changed, 672,000 jobs may not be generated by 2035, as currently projected. This would result in R$ 25 billion in tax revenue losses by 2027, and the sector could lose R $ 13.3 billion by 2035 – the year in which 75.38 million tons of CO_2 will have been released into nature for the generation of electricity from traditional sources.

> *"At this stage, solar deserves encouragement and not a change in the rules"*

Which market segments and types of projects do you think would be most affected by this new net metering regulation and why?

Undoubtedly, the most affected models would be large projects, where there is an essential concern that changes would significantly affect payback. It is important that the rules are maintained for the growth of this business.

Earlier this year, Brazilian President Jair Bolsonaro ruled out the proposed tax on solar energy after the power regulators ANEEL said they were considering applying a fee on small, net energy metered solar systems. Do you think that the popular approval of this proposal could still carry some weight against the changes currently in discussion?

If RN 482 is approved as currently proposed, it may simply make investment in solar energy production unfeasible. The Federal Chamber is already preparing a bill to ensure that there will be no taxation of solar energy for users of distributed generation (DG) and to prevent changes from being promoted, exclusively, by the regulatory agency (ANEEL).

Photo: Aldo Solar

Aldo Pereira Teixeira is the founder and president of Aldo Solar, one of the largest PV distributors in Brazil.

I believe that together – the Federal Government, the National Congress, entrepreneurs in the solar sector, and the general public will be able to resolve this issue. We will fight together for the strengthening of a Solar Brazil. The subject was more heated in late 2019. We started 2020 with less concerns about changes to the rules.

Transportation infrastructure is one of the main challenges in Brazil. How do logistics present challenges and strategic opportunities for the solar business?

Brazil is a country of continental proportions and the transport infrastructure really hinders the way, and increases costs for entrepreneurs in all segments. But, as mentioned, it is necessary to carefully plan the logistical process, which is also one of the keys to Aldo Solar's success.

We've invested a lot in logistics optimization, as we consider it a differentiator for customer satisfaction and for our business. We have a close partnership with the Port of Paranaguá, in the state of Paraná, where the company has an exclusive space for more than 500 containers and cargo clearance, and with Sudmar Transportes for faster equipment transportation to our headquarters. We have partnerships with major transporters in Brazil that are specializing in the solar segment which this is very good for the growth of the business.

Earlier this year, Aldo Solar partnered with Growatt. Why did you decide to partner with Growatt? How do their inverters compare with competitors?

Growatt is one of the fastest growing worldwide companies in the inverter market. It took only 18 months since its foundation to become the top brand in China in its segment. A differentiator of these inverters is the possibility of using the Growatt Online Smart Service system in which it is possible to monitor, manage and control the photovoltaic systems remotely.

Growatt`s excellence has been recognized by the market. Recently, it was awarded the Top Brand PV Europe Seal 2020 and Australia Seal 2020 award, from EuPD Research, which attests to and recognizes the manufacturer's leading position in terms of product reliability, market penetration, brand awareness and customer satisfaction. By 2018 it had become the world's third largest single-phase PV inverter supplier. Together with Growatt, we can provide quality service for customers.

> *"Brazil is a country of continental proportions and the transport infrastructure really hinders the way"*

What is expected from this new partnership?

We hope to extensively spread solar energy and offer excellent cost-benefit conditions to produce clean, cheaper energy to all Brazilians. We want to be Growatt's largest distributor outside China – and we strongly believe in the manufacturer's on grid and off grid solutions.

What makes you decide to partner with one company over another?

We always seek to establish partnerships with the best partners in the market that offer quality equipment, and an excellent cost-benefit ratio. We value win-win relationships and compliance with the negotiations that are discussed and aligned by both parties. Product reliability and customer service are two key aspects to be considered when we make decision for partnership. With regards to Growatt, we understand their products and services very well. Their service center in Brazil in Mogi das Cruzes and the OSS system make Growatt an impressive company.

What are your projections for the residential DG market in Brazil for 2020? And beyond?

According to forecasts by ABSOLAR, the Brazilian Association of Photovoltaic Solar Energy, in 2020 the country should reach 5.4 GW of DG power, 260% growth in relation to the 2 GW produced last year. In 2019, 171,000 solar PV systems were connected to the grid. By the end of the year, more than R$ 16.4 billion should be invested in the installation of solar PV systems to serve homes, businesses, industries, rural properties and public buildings, considering the average price of the systems, by power range.

Today, photovoltaic solar energy represents only 1.5% of the electricity mix in Brazil. In ten years, the Energy Research Company (EPE) believes that we will represent 10%. In 20 years, by 2040, Bloomberg suggests 32%. This will be the moment when solar energy will surpass hydro. pv

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